Bionics

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Publication date:
2005

Document Version
Publisher's PDF, also known as Version of record

Link to publication from Aalborg University

Citation for published version (APA):
Stokholm, M. D. J. (2005). *Bionics*. Architecture. A&D Skriftserie No. 51

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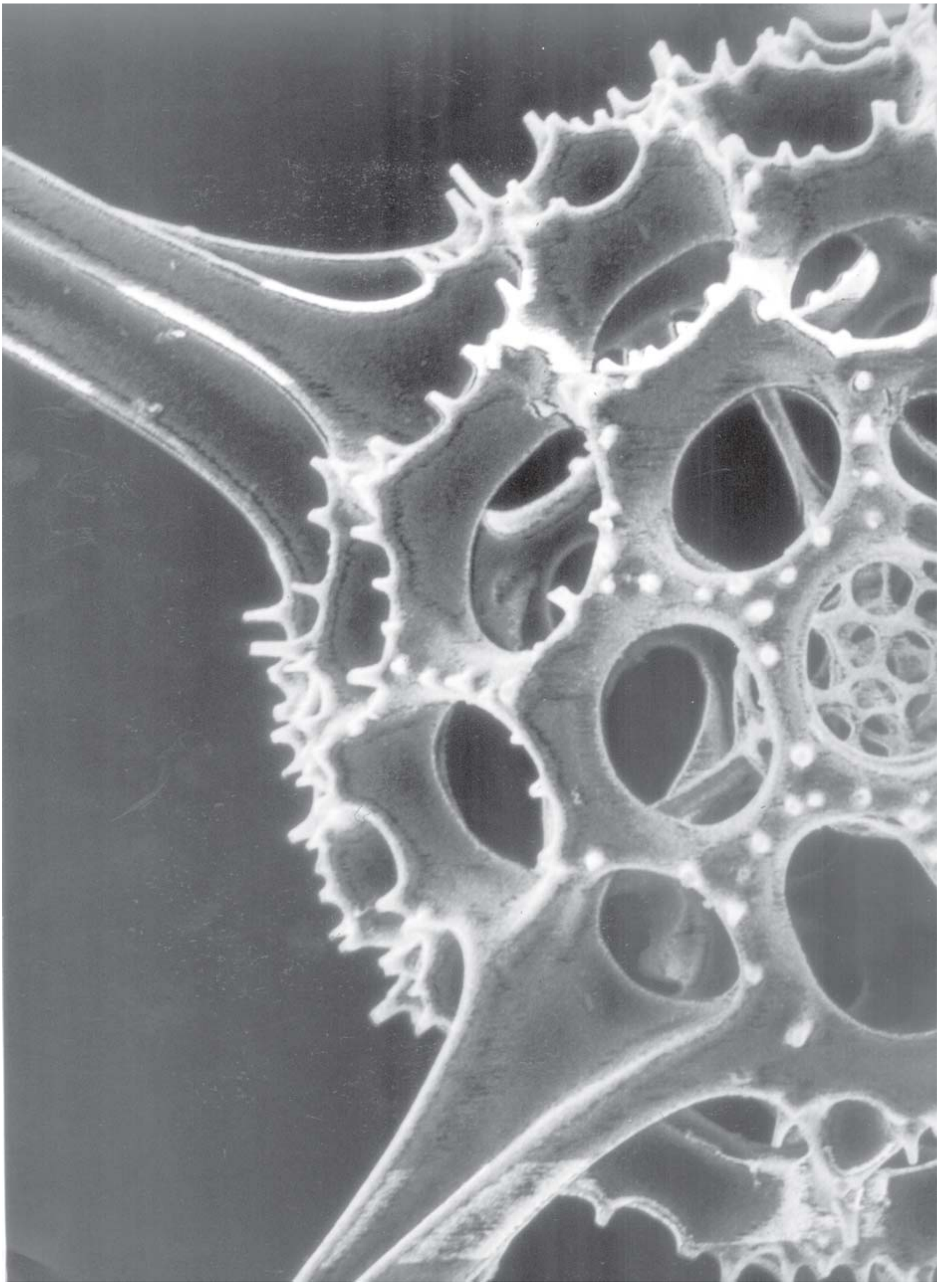
Students' guide for mini project, 4th terms 2006, Architecture & Design, Aalborg University



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Students' guide for mini project on 4th term 2006,
Architecture & Design, Aalborg University

Januar 2006

Marianne Stokholm

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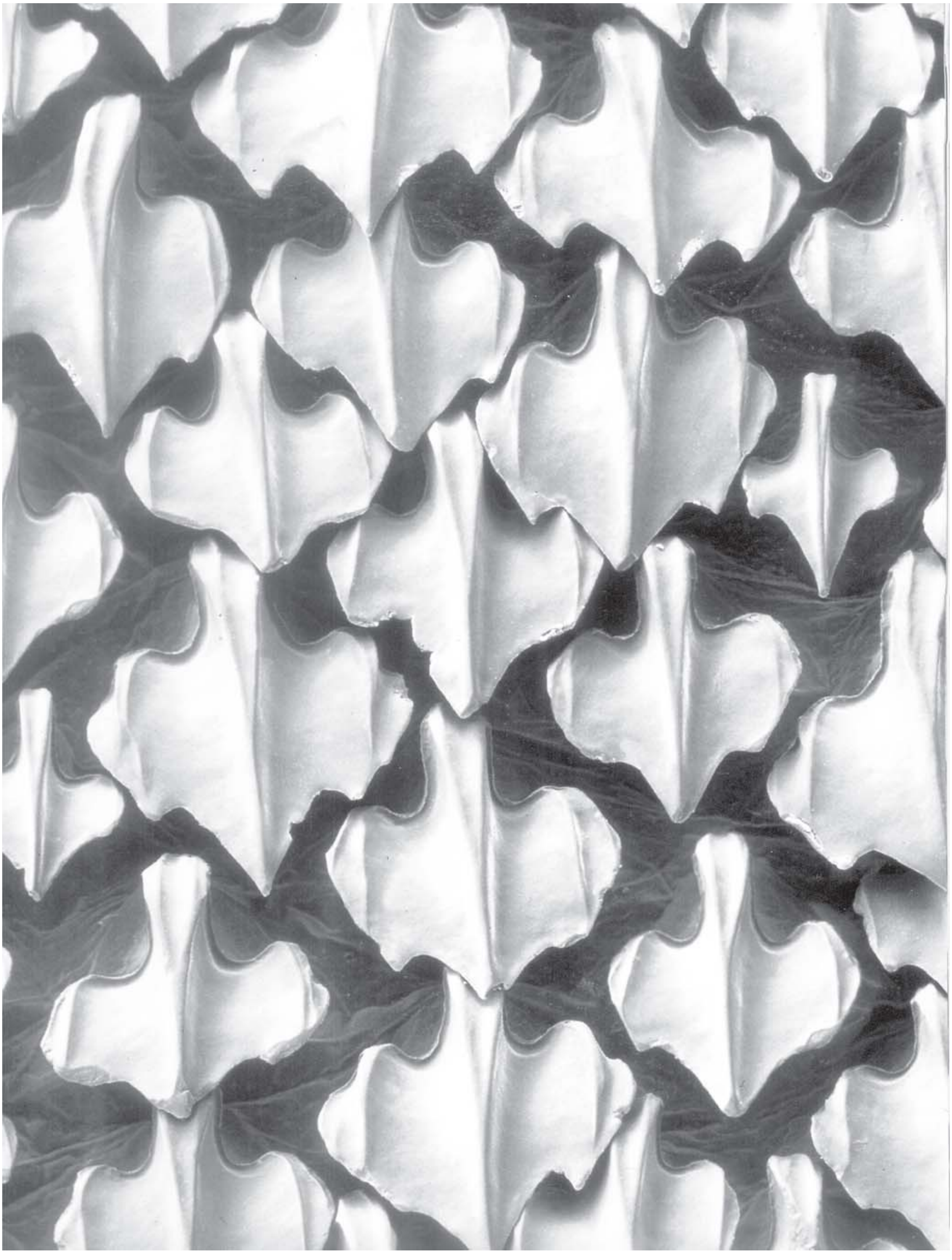


Introduction

Bionics is an interdisciplinary field on the way to establish itself a science. Bionics deal with mans use of structures, methods and processes found in biological systems in relation to technical development.

To look for inspiration in nature or to study nature intensively in order to learn from it is not new to artists and engineers. The works of Leonardo da Vinci (1452-1519) are some of histories best documented examples.

The concept of bionics has its birth in the US, but has especially gained ground in Germany and Italy. The aim is, through the structuring of observations done in nature, to simplify the transformation of nature given functional principles for use within the technical area.

The reason for Architecture & Design to incorporate bionics in the education of designers is, that this subject fits our focus on methods in integrated design including interdisciplinary team work.

In 2006 a mini project in bionics is offered to A&D students for the 6th time. The project is organized and carried out by an interdisciplinary team from Aalborg University including architects, industrial designers and engineers, who are especially interested in bionics.

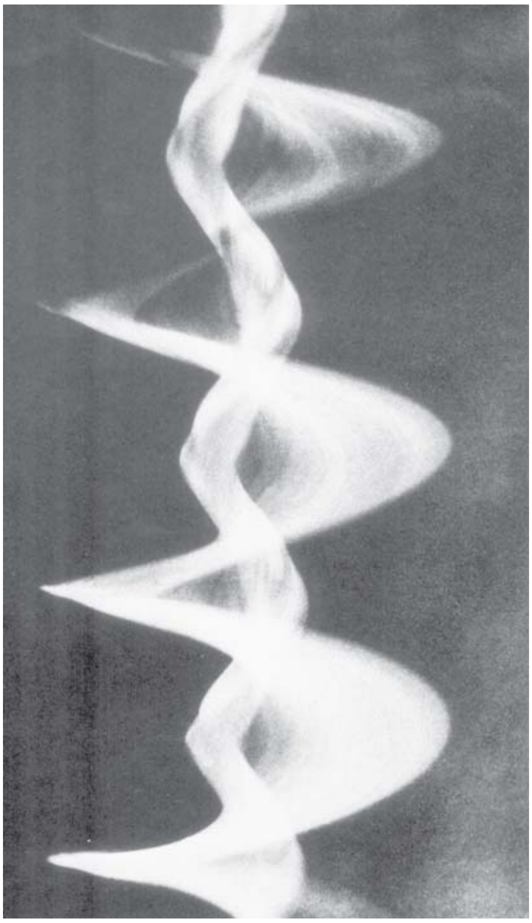
The program for the mini project Bionic, include lectures as well as project work. Through the lectures the different teachers will present their knowledge and experience concerning bionics and bionic design. The project part is structured in stages with a tight guidance concerning methods, but freedom in the choice of specific study subjects and project theme. This frame is chosen to reach the aim of the mini project and at the same time let the students free to follow personal and professional interests.

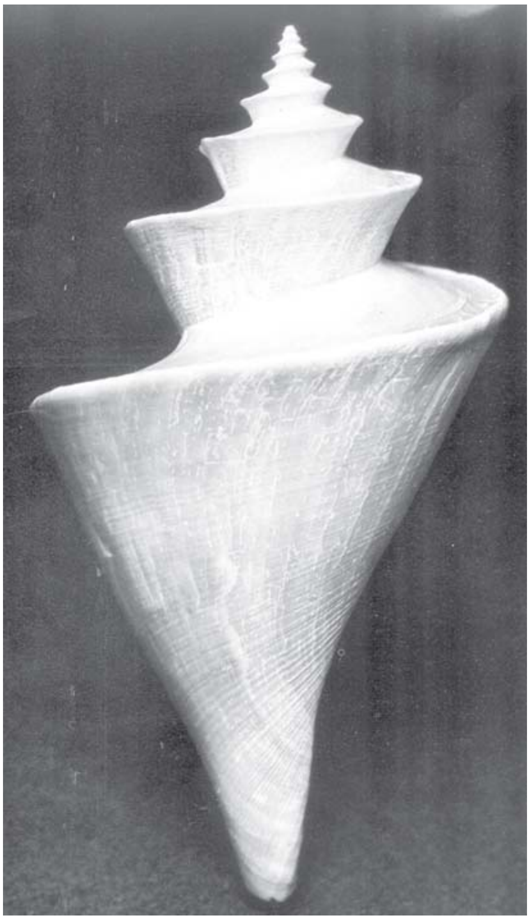
The total programme will have the form of an intensive workshop and the results will be exhibited at the end.

The duration of the bionic miniproject is 3 weeks.

We do hope that you all will join the mini project with a lot of curiosity, do your utmost to create interesting and qualified results and last but not least surprise yourself with innovative solutions.

Marianne Stokholm





Bionic Mini Project

Description from the Students' guides for 4th semester.

Extent

4th semester: 7 ECTS incl. 2 ECTS PU-course in BIONICS.

Purpose

The purpose of the mini project is, through an intensive project period, to test methods, which enable the students to analyze natural principles and apply the principles by the development of a new design.

Content

The project unit is based on what the nature can teach us about design.
Contrary to man-made design, which builds on the rational and intuitive design methods, the "design" of nature is made through evolution. Such a superior method can give us valuable knowledge, even without a fully scientific understanding, of the fundamental principles of natural design.
With BIONICS as value foundation and method the students are supposed to choose and analyze biological systems and convert the qualities and principles into a new design.
Work with BIONICS can begin with a problem, where inspiration for at new design is searched through analyses of biological systems - or begin with a fascination of a biological system as the basis of inspiration for at new design.
A special guide for the mini project is made, in which the task is further specified.

Performance

The themes of the mini projects are introduced on the 1 st February 2006.
Enrolment deadline for Bionic mini projects is on the 1 st Februar at 12.30.
The mini project will take place from the 1st February to the 21st February 2006.

The students will work in groups and individually and hand over individual projects.
Guest students are offerede to participate in the mini projects.

Supervision during the mini project

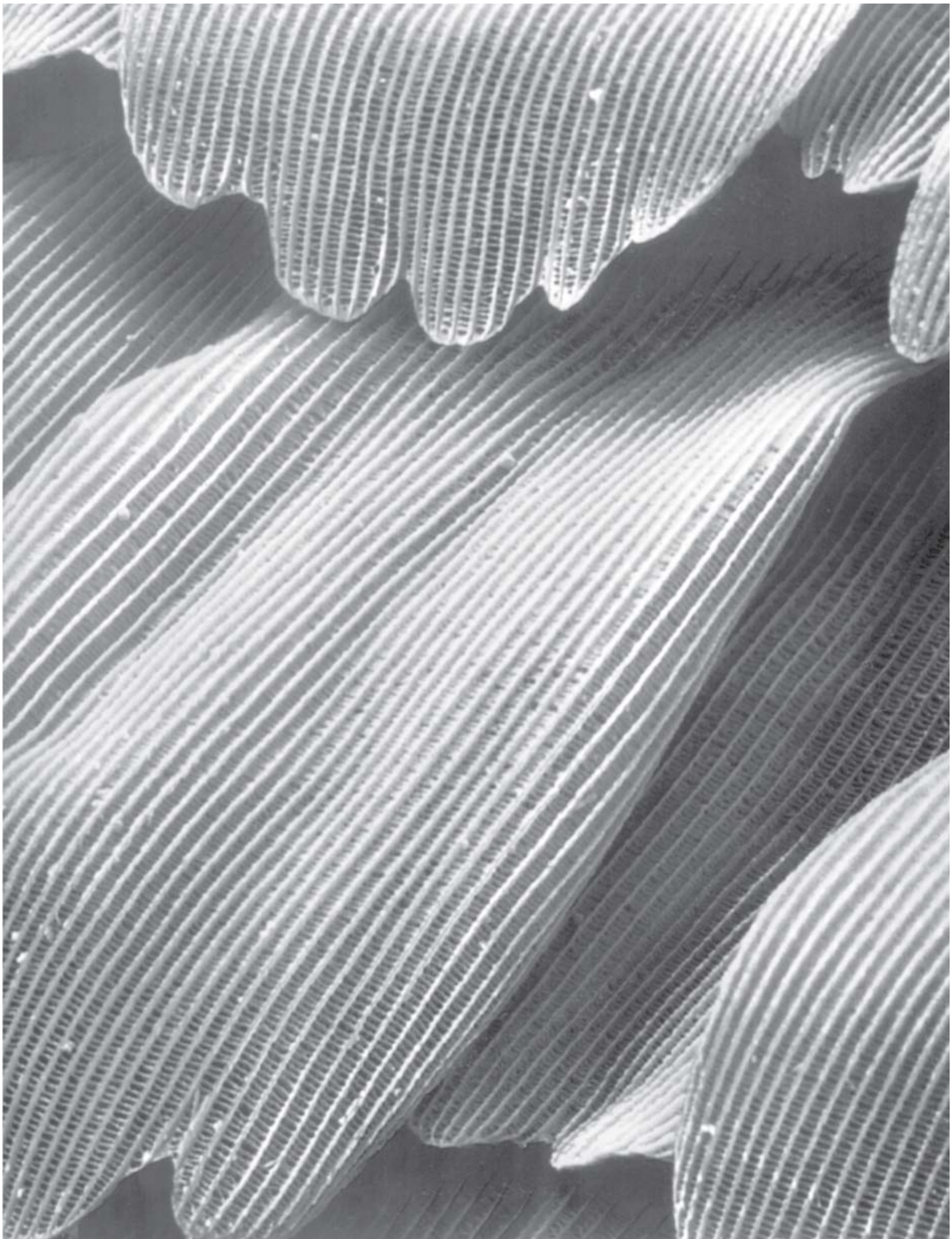
In so far as it is posible supervision will be available every day during the mini project. An interdisciplinary team consisting of industrial designer, engineer and architect will perform supervision.

Evaluation

The mini project is to be handed in on the 21st February at 8.00. Standards will be specified further in the guide BIONICS.

Evaluation of the mini project will take place on the 3rd Marts.

The project unit will be marked passed/not passed.



Bionics

Nature was always a source of inspiration for man creating tools or expressing himself artistic.

Works by Leonardo da Vinci and William Morris are examples from history. From our time Callatravi, Collani and Starck could be mentioned.

Nature has inspired artists, architects and engineers in many fields including shapes, patterns, structures, construction principles and technical solutions. Often nature has just been an ideal and not the solution. For innovative breakthroughs a transformation of the contained principles of function is required.

The concept of bionic appears for the first time in USA in 1960 as the designation of a new science, which connects biology and technology. At that time, under the air and space program, the aim was to provide the product development activity with new impulses through interdisciplinary corporation between the two fields.

One project from that time was the development of surfaces for ships and torpedoes modelled on a dolphin. Dolphins are able to reach a high speed under water because they are able to reduce the creations of whirls on their body surface.

Beneath the outer layer of their skin there is a mechanism which is elastic, transformable and which consists of thin channels. These channels contain a fluid capable of incorporating energy of turbulence and by doing so reducing the braking effect of the whirls.

A lot has happened since the first time, when punctual biological phenomena were the subject of bionic studies. Biological discover has been structured to simplify the implementation within the technological area. Bionics is on its way to establish itself on a scientific level, even though the big breakthrough is still ahead.

Especially Italy and Germany have shown an interest in bionics. The German biologist Werner Nachtigall has since the 60ties been occupied with bionics. His writing about the subject is among the best.

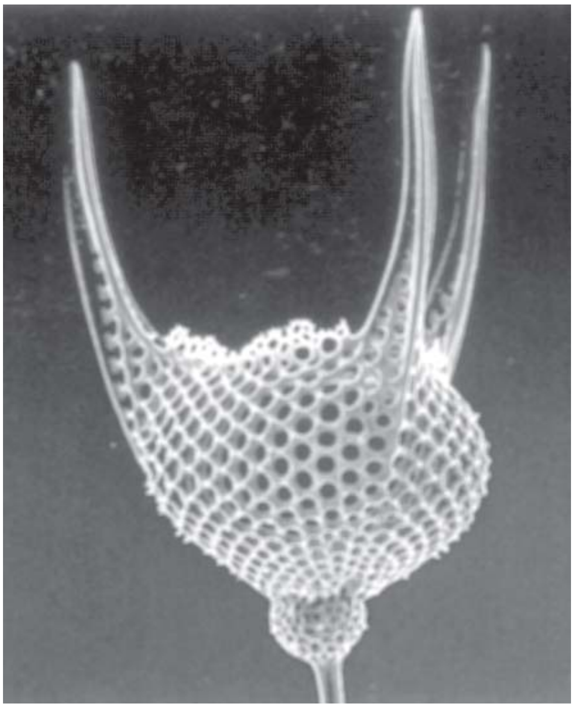
The Italian designer Carmelo di Bartolo in the 70ties founded Instituto Struttura Naturali at the school of design in Milan called Instituto Europeo di Design. Together with a few others the two of them developed a concept for a European set of requirements for science within bionics called *"Nature oriented Design and Bionics"*, which will secure that they in a broader perspective can add new knowledge about bionics.

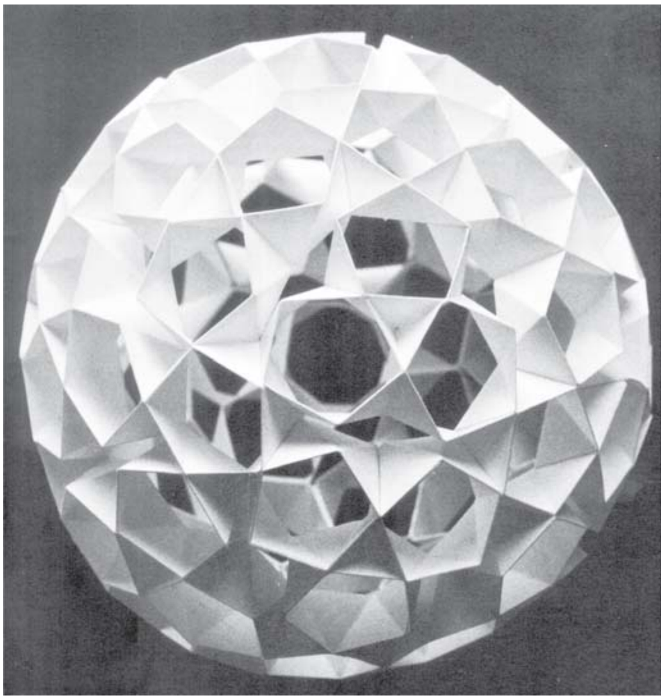
Through the years a number of designers have been educated in bionics at Instituto Europeo di Design. Based upon analyses of various natural subjects they have designed products, components and systems.

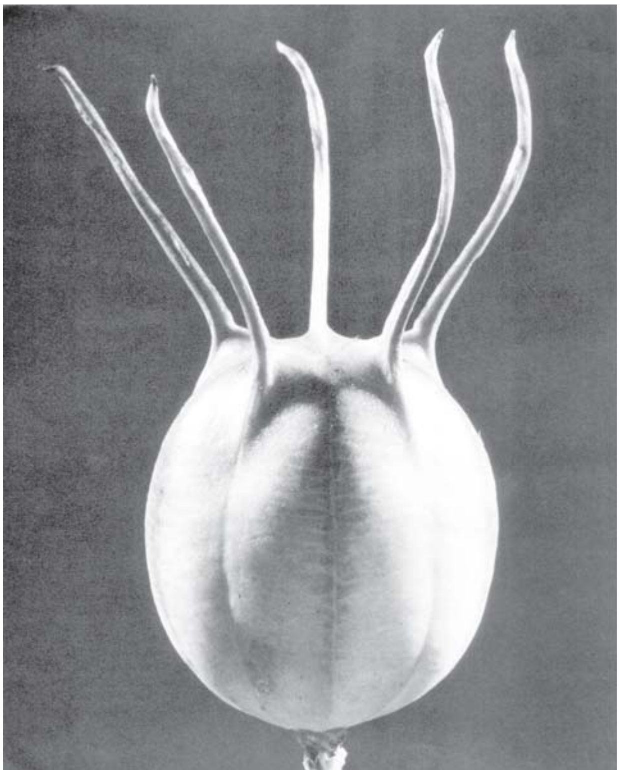
In 1996 an exhibition called "Bionik, Zukunfts-Technik lernt von der Natur" organized by SiemensForum München/Berlin and Landesmuseum für Technik und Arbeit in Manheim. The exhibition was on show several places and spread the knowledge about bionics.

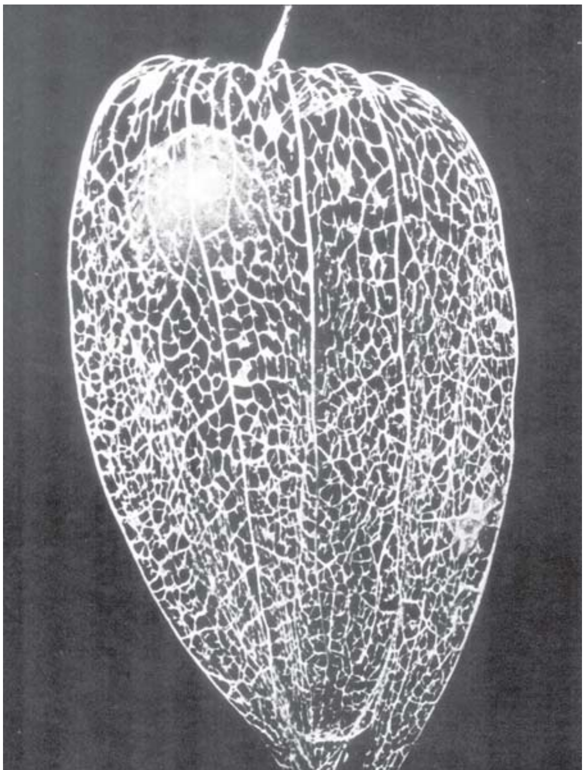
Bionics 1983

„Interdisciplinary field within biology and technology which covers systematic studies of functions, relations, structures, and processes in biological systems and the









transformation of these to the solutions of primary technical and technological problems".
(Meyers grosse Taschenbuchlexikon, Manheim, 1983)

Bionics 1993
„Bionics as science is occupied systematically with the transformation and use of constructions, processes and principles of development from biological systems".
(Dieter Neumann, Bionik-Technologieanalyse, 1993)

Bionics 1999
„Bionics has something to do with the technical transformation to and application of structures, methods, principles and developments found in biological systems. The term bionics is originally formed by the words of bio and electronics. Bionics stands for a new interdisciplinary area of research that combines biology, technique, architecture and mathematics".
(Franco Ladottea, Design DK 1:1999)

Biostrategy
Biostrategy is oriented towards ideals from the living world. It persists that these ideals, which has developed over millions of years and created the most efficient solutions, can stand as examples for the planning of future structures of the civilization.

Bionics is a tool - not more but not less
- Bionics is not a cure and not a copy of nature
- Bionics is a tool which may not must be used
- Bionics is no universal tool for solving problems, but may in the best way be an excellent assisting tool

10 bids on bionic design
Good design means optimal design. The key lays in the following basic principles for natural construction, worked out by Werner Nachtigall, Carmelo di Bartolo, Jürgen Hennicke and Gabriel Songel.

1. Integrated instead of additional construction
2. Optimization of totalities instead of maximization of singular parts
3. Multi functional instead of mono functional
4. Adjustment to the environment
5. Energy save instead of energy waste
6. Direct and indirect use of solar energy
7. Limited lifetime instead of unnecessary durability
8. Total recirculation instead of piling garbage
9. Network creation instead of linearity
10. Development through trial and error

(Werner Nachtigall, Das grosse Buch der BIONIK Neue Technologien nach dem Vorbild der Natur, 2000)

Characteristics of biological materials
1. Overlapping materials while produced. Materials are often placed in layers, time

after one another, and each layer having its own specific structural and functional specification.
Cobweb

2. Biological materials are often formed successive. One small plate being placed after the other in an overlapping manor.
   Sea-Algae*: Coccolithophoriden*

3. Biological materials are often strictly functional and still structured in a hierarchy
   Sinew*: When you separate them, continuous bunches of heterogeneousness are created until at the end you reach the level of protein molecules.*

4. Biological materials often present compartments of functionality
   Vein walls*: Anti stitch materials, elastic materials, materials which contract and so on.*

5. Functional differentiation using forces of the surface during creation
   Radiolarer*: (Small sea animals) Their often magical forms are not created molecule by molecule but exposed in one singular mould process, by which the forces of the surface continuously are controlled resulting in formation of predetermined structures.*

6. Biological materials are often highly specialized and build in many layers
   Cuticle of insects*: The directions of these slides are crossing one another resulting in an anisotropy material even though the singular layer is isotropy.*

7. Biological materials are often ultra light
   Butterfly scale*: Chitin is shaped in a gracious and extremely light frame construction.*

8. An unconventional way of sandwich construction is often found in biological materials
   Bird skulls*: They are very light and consist of a sponge like bone substance between to covers of membranes.*

9. There also exist peculiar poly component materials made by chemical identical but physical different components
   Sea Urchin Tooth*: The hardness and simultaneous elasticity is produced by two interlinking calcium modifications. One is pressure stable the other pulls stable. Chemically they are identical calcium carbonates.*
10. Many biological materials are self repairing
    Bones

11. In general biological materials are multifunctional
    Butterfly egg*: The wall consists of chitin, which is constructed to serve different purposes as for example not to allow transmission of liquid but very well gas.*

12. Biological materials in general have a low lifetime, are totally biodegradable, and can be recycled.

These two statements are maybe the most important in relation to products developed by civilization.

Epilogue

Thinking within bionics increasingly move towards more comprehensive systems. It means not only in isolated construction principles but in more basic principles from the natural evolution, which is the ideal.

But evolution is not undisputed. Stephen Jay Gould is questioning the classical imagination about the progressively transformation of the species over millions of years and suggests a theory where in reality the development is happening in abrupt leaps.

"There is a lot of horrible design in nature. It is pure post rationalization, when you analyze the anatomy of the creations and suggest scenarios on, how each and every characteristic is optimal as a sign of adoption to the environment. Lots of characteristics are just consequences of something else"
(Stephen Jay Gould and Niles Eldredge, Punctual Equilibrium, 2000)

Also bionics is not undisputed. Up to now bionics has not reached the goal as an established science. The number of successful projects, built upon systematic bionic research is still fairly limited. Still one is fascinated by the possibilities provided by bionics. To work with bionics opens a world source of inspiration, enlarge the catalogue of design methods and sharpens the understanding of totalities and relations. Therefore bionics is interesting when you are searching for new methods and perspectives of creative work.

Literature

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Werner Nachtigall
Deutche Verlags-Anstalt Stuttgart/München, 2000

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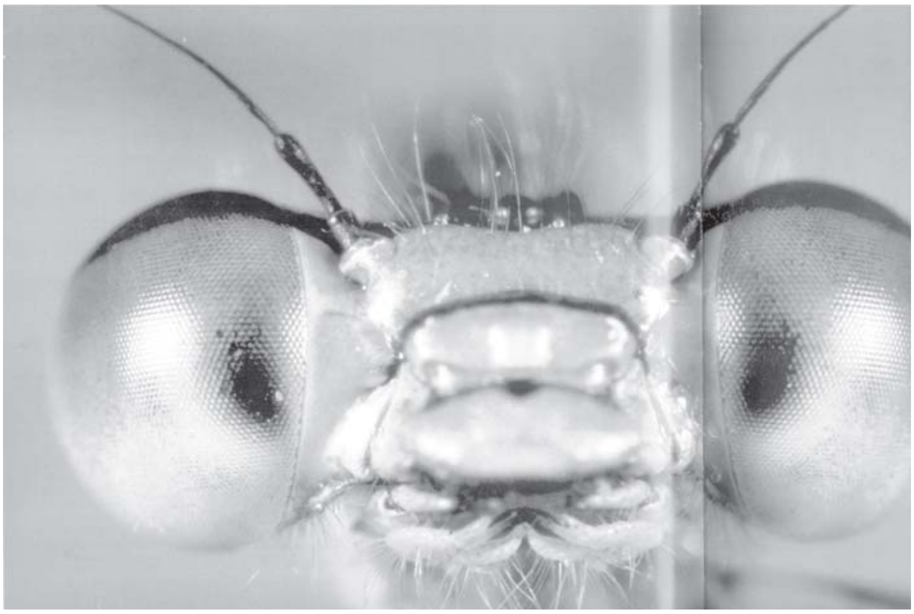
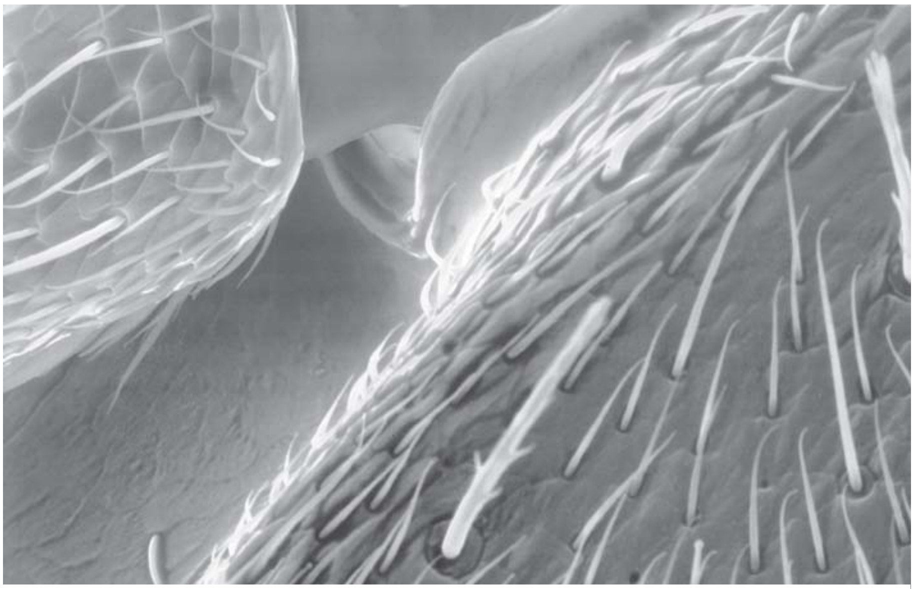
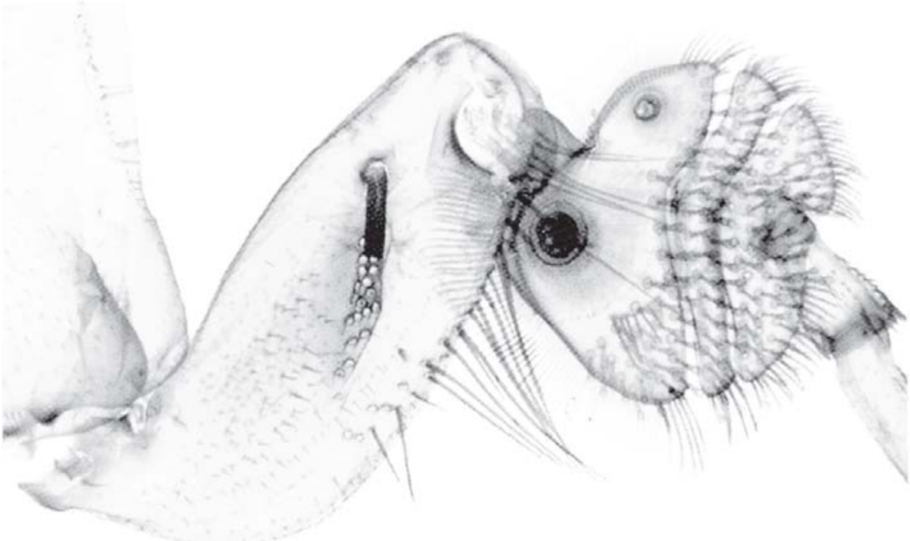
Punctual Equilibrium
Stephen Jay Gould and Niles Eldredge, 2000







Lectures

Aims

The aim of the lectures is to provide an understanding of Bionic as a field that incorporates many different disciplines and a wide range of expertise. These lectures will support and provide inspiration to the project work through the presentation of sources of Bionic knowledge, methods of design and realized examples.

Contents

The lectures will cover themes within architecture, industrial design and engineering, together with an understanding of design methodology and methods of analysis of natural objects. The lectures will be given by a multi-disciplinary team of architect, industrial designer and an engineer from Aalborg University.

Overview of lectures

Industrial designer Marianne Stokholm

- Bionics and Bionic Design
- Bionic analysis
- Bionic principles
- Bionic design

Architect, Thomas Arvis Jaeger

- Geometric versus organic
- „Strømningsformer“

Engineer, Jørgen Kepler

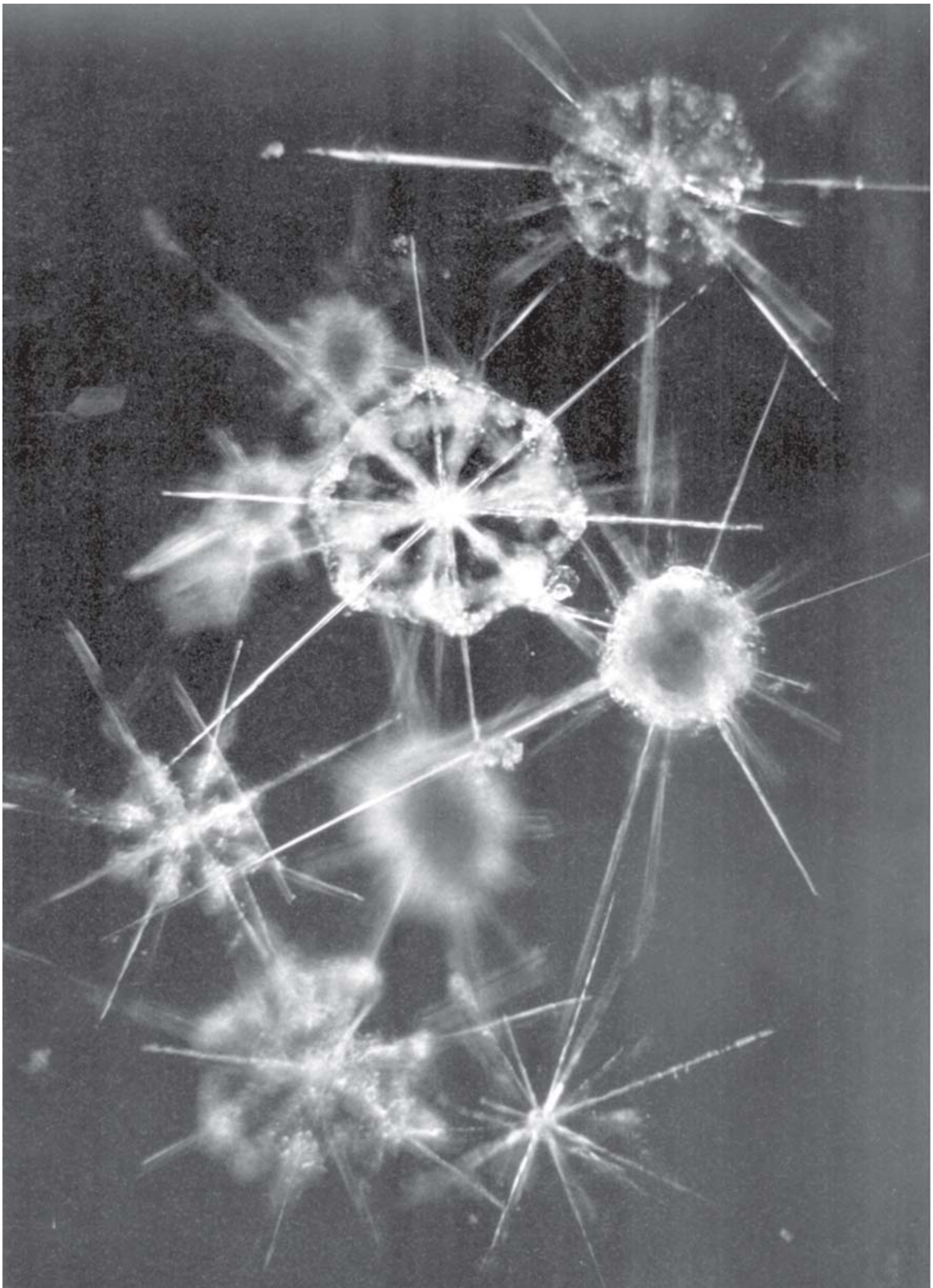
- Evolution
- Leight weightstructures in nature

Engineer, Lasse Rosendahl

- Aerodynamics

Industrial designer, Stefan Froholdt

- From nature to idea; Examples, strategy, and design



Project description

Aims

The aims of the project are to, through an intensive and controlled design exercise, to test design methods that provide the student with the ability to analyse precedents within nature and use these design principles in the development of new innovative design.

Contents

The project comprises

- The analysis of qualities and structural characteristics found in the natural world, with regard to construction, form, and function.
- The deduction of general and specific principles within nature and the transformation of these through a process of abstraction to a model.
- The implementation of selected principles as actual components, products, systems and material.

Project stages

The project is divided into four stages:

- 1: Analysis
- 2: Transformation
- 3: Implementation

The purpose of deviding the project into stages is to strengthen the design process and ensure that the aims of the mini-project are achieved. Each stage builds upon the results of the previous stage.

The working process

The manner of working will alternate between group and individual work. In the initial stage of analysis, teams will be established, as the basis for the analytical research of the selected topic. Subsequently the groups will chose a number of natural objects that will be divided amongst the members of the team for further analysis. Each individual will analyse and evaluate their respective object, presenting their resulting conclusions to the rest of the group.

In the transformation stage, the individual student will translate his/her results into a table of general or specific principles, which will provide the basis for the development of a model. The models will be constructed individually.

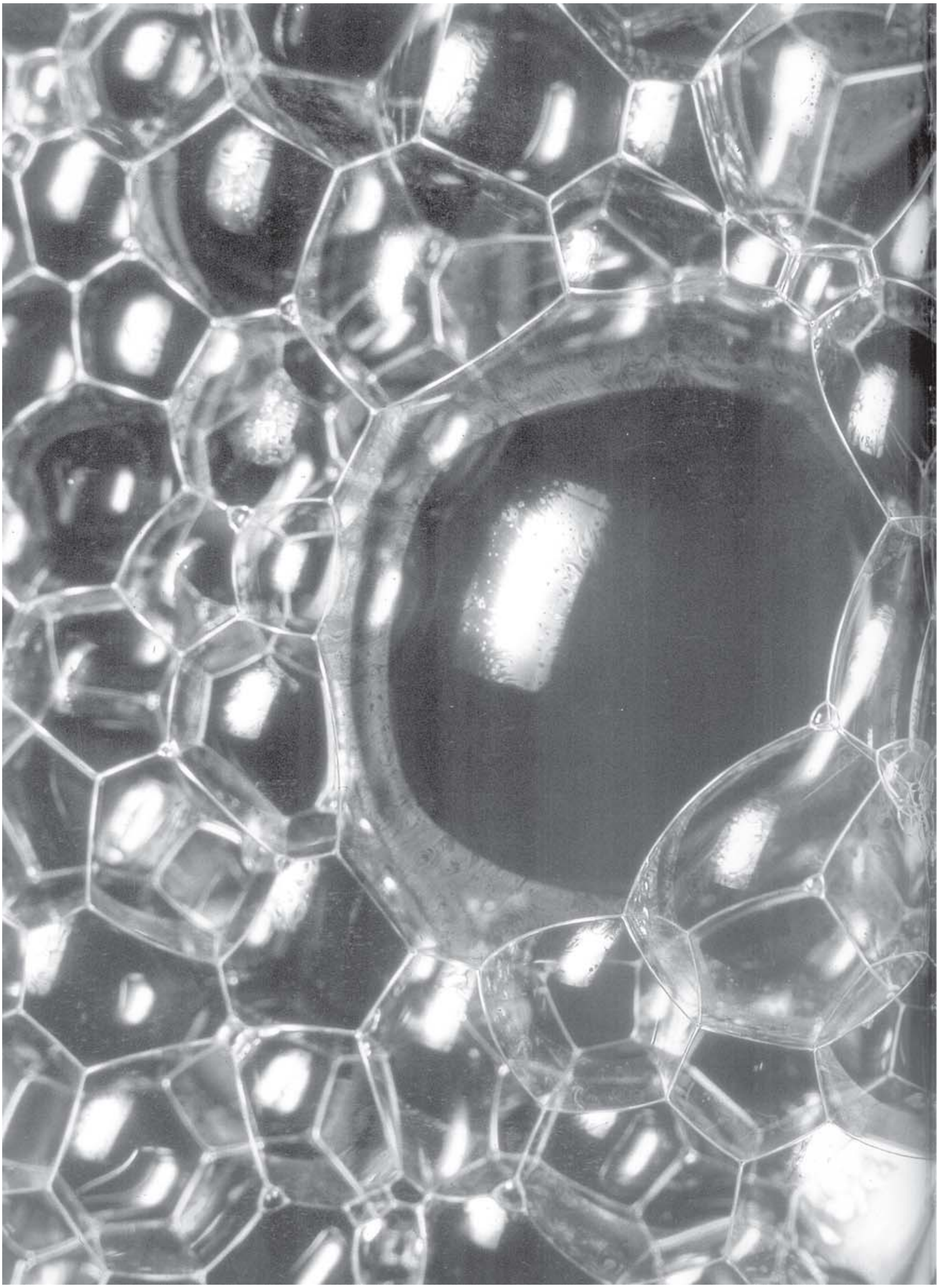
In the final stage, each individual student should choose a specific project within on of 3 themes and 1-2 principles, which will provide the basis for the design of a resulting product, system and material component. The resulting proposal should be based on the preceding research and studies. It should be presented as a graphic presentation, with the preferable addition of a supplementary model.

At the conclusion of the mini-project, each individual student should present the results of the previous stages, prior to their final project design proposal, so that the progress from analysis through transformation to implementation is clearly evident.

The anticipated results

At an individual level it is anticipated that the student becomes more aware of nature as a source of inspiration, develops new areas of competence with regard to design methodology and exceeds oneself in terms of innovative design.

For the Institute of Architecture & Design, it is our expectation that we will build upon our experience with integrated design and see exciting results in terms of innovative project proposals and documented design process that will help establish a profile for the Institute of Architecture & Design.



Project stages
Stage 1: Analysis

Aim
The aim of this stage is to examine a natural object or element, in specific the relation between form and structure and the geometry within as well as the functional principles. The result of this study is related to the practical utility – of the natural object.

Content
A main topic is chosen and a specific natural object selected. The natural object/element is brought in for studies. The natural object/element is dissected and studied using visual aids as copy machine, camera, microscope and drawings. Further information's are selected from books and internet. The dissections are analyzed concerning the geometry of form and structure. The registrations are visually represented using photos and drawings. Further more the principles of form-structure are studied and represented in a visual specification of the geometrical principles. Finally the functional principles and utensil capacity of the natural object/element is studied, described and related to the above studies.

Progression
- Introduction to the content and procedure of the stage.
- Formation of group on topics and selection of a natural object/element.
- Dissection and studies of form and structure in the natural object/element.
- Studies and specification of form-structure principles and functional principles.
- Description of utensil capacities.
- Presentation of results.

Presentation material
The presentation shall comprise 1-2 A3 sheets including registration, analysis and specifications of the form- structure relation of the natural object/element, visualization of functional principles and a written description of the utensil capacity. The headline must include name of the natural object, students name and semester

Topics for Stage 1: Analysis

Topics

1. Building
2. Folding & packing
3. Flying & swimming

Natural objects for analysis

1. Building
    - Trees
    - Plants
    - Skeletons
    - Shell fish
    - Seed shelters
    - Soap bubbles
    - Animal Architecture
    - Ect.

2. Folding & packing
    - Fruits
    - Leaves
    - Vegetables
    - Flowers
    - Seed shelters
    - Cocoons
    - Ect.

3. Flying & swimming
    - Birds
    - Insects
    - Fish
    - Sea mammals
    - Seeds
    - Ect.

Stage 2: Transformation

Aim
The aim of this stage is to gain a deeper understanding of the form-structure relations and principles as well as the functional principles found in the analysis of the natural object/element by transforming these principles to a geometrical and mechanical model.

Content
Based on the results of the analysis a physical or digital model is produced demonstrating the principles found in the natural object/element.

Progression
- Introduction to the content and procedure of the stage.
- Reviewing the results of the analysis.
- Planning and production of a geometrical and mechanical model.
- Presentation of the model together with the material from Stage1: Analysis.

Presentation material
The presentation shall comprise one or more models using the form-structure principles and mechanical principles transformed to a working model. Physical models can be made of cardboard, wood, steel and Lego. The model should have a label referring to the natural object/element analyzed and the name of the student.

Principles
- Structures
- skins
- Mechanics
- Materials
- Surfaces

Stage 3: Implementation

Aim

The aim of this stage is to implement principles of form-structure relations found in the analysis of natural objects and elements in the development of a new design and in so doing gain an understanding of the potential source of inspiration that a design can derive from nature with regards to construction, form and function.

Content

The main theme of the design project is cover/cabinets related to a product or a building. Within the theme a specific topic is chosen according to the professional interest and relevance to the principles of form-structure found in the analysis of specific natural objects and elements. Examples of specific topics are listed below. In regards to cover/cabinets the design of the whole, parts, joins and material are to be considered. The project work may focus further on one of these aspects providing solutions on a more detailed level.
The focus is on the form-structure and construction-material relations and their integration.
The project work is not intended to include the total design of the product or building.
A second theme on advanced innovation is set up as an alternative.

Progression

- Introduction to the content and procedure of the stage.
- Selection of principles from the analysis and a specific topic for design.
- Implementation of principles within the design.
- Planning and production of project material.
- Exhibition of project material from all stages.
- Evaluation of the results of each project including works from all stages.

Presentation material

The presentation shall comprise 2-4 A3 sheets and one or more physical models which visually explain the design solution concerning form-structure, whole-part and construction-material. Detailed design and specifications on elements like parts, joints, material structure or material construction may further be presented and provide a god supplement to the specification of the design solution.
Remember to headline the project material with the specific topic analyzed as well as the specific topic for design so that the source of analysis and transformations can be traced, in order to reflect the total process.
Material from former stages has to be delivered together with the material of this stage.

Topics for Stage 3: Implementation

1. Building
SPACE
Interior/exterior
- structure/form
- joints/skin
- climate/light
- stability
- flexibility

2. Folding & packing
PACKING
Container/cover
- structure/form
- strength/weight
- protect/distribute
- space efficiency
- climate/light

3. Flying & svimming
AUTOMOTIVE
Vehicle/mover
- structure/form
- joints/skin
- aerodynamics
- motion/friction

Overall project frame

Topics	Analysis	Transformation	Implementation
Actions	*Natural objects*	*Principles*	*Design object*
1. Building	Trees	Structures	SPACE
	Plants	Skins	Interior/exterior
	Skeletons	Mechanics	-structure/form
	Shell fish	Materials	-joints/skin
	Seed shelters	Surfaces	-climate/light
	Soap bubbles		-stability
	Animal Architecture		-flexibility
	Ect.		
2. Folding & packing	Fruits	Structures	PACKING
	Leaves	Skins	Container/cover
	Vegetables	Mechanics	-structure/form
	Flowers	Materials	-strength/weight
	Seed shelters	Surfaces	-protect/distribute
	Cocoons		-climate/light
	Ect.		-space efficiency
3. Flying & swimming	Birds	Structures	AUTOMOTIVE
	Insects	Skins	Vehicle/mover
	Fish	Mechanics	-structure/form
	Sea mammals	Materials	-joints/skin
	Seeds	Surfaces	-aerodynamics
	Ect.		-motion/friction

Exhibition and evaluation

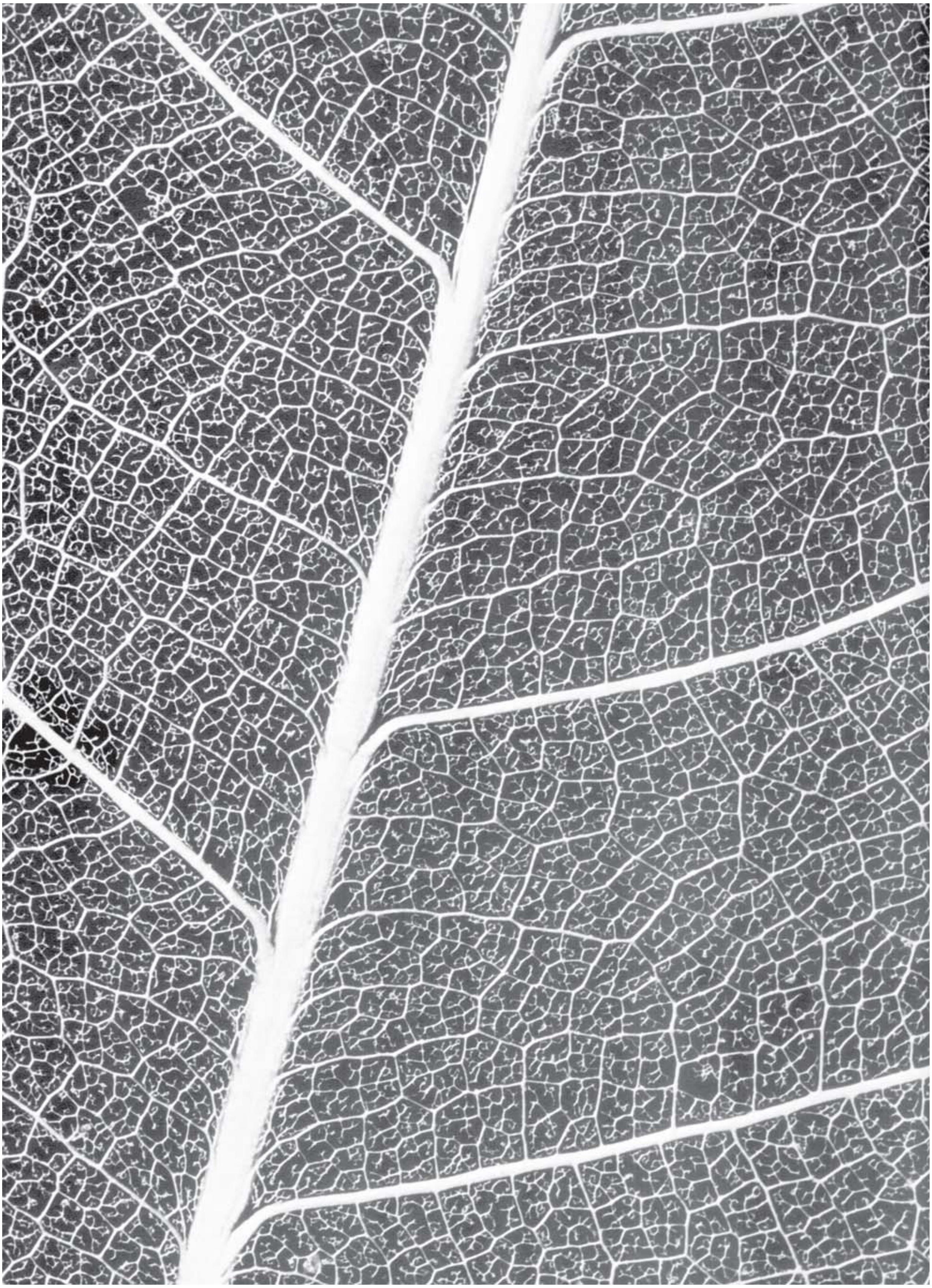
The students submit their presentation material for the mini-project, which is then organized as an exhibition

An evaluation will be made on the basis of the submitted project material, which shall present the design proposal and document the underlying design process. There will be placed emphasis upon whether the design proposal demonstrates an ability to analyze sources of natural design, transform them and implement these in the context of a new innovative design.

Teachers will evaluate the projects and present their comments to the students at the end of the workshop. Finally the results of the evaluation (passed-not passed) will be presented to the students when the miniproject is evaluated.

NB!
All project material has to be submitted to a database at the end of the evaluation.

So far it is only intended that the Bionic mini-project concludes with an internal exhibition. However, should the results be of an exceptional character, an open exhibition will be considered, together with the possibility of publishing selected material.



Facilities

Course material

A course description and program is provided before start of the project. At each stage, an introduction will be given and the parameters of the project and its presentation will be further defined.

Literature

In relation to the project, a special selection of books will be available. A literature list is provided in this compendium. Furthermore a compendium comprising a number of selected articles is made available for self-copying. The material is organized by Jacob Hansen in the A&D Liberry.

Workshops

The following workshops are available to the students during this project:

- Model workshop in the basement of Gammel Torv 6
- IT laboratory at Gammel Torv 6
- Model laboratory at Institute 15 Pontoppidanstraede 101

Microscops will be avaiable during the miniproject.

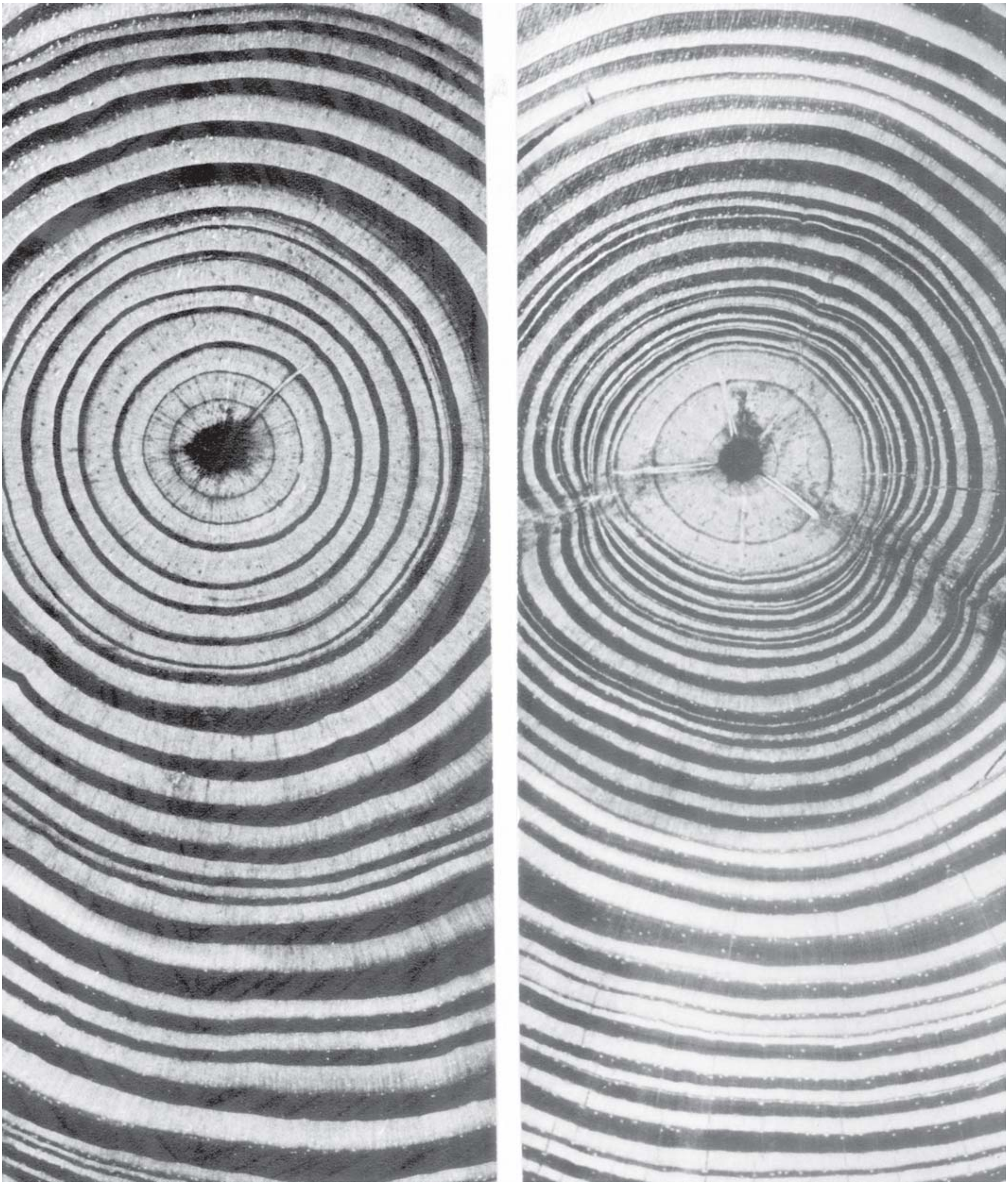
Location

Locations for lectures, introductions, presentations and supervision are organized to support the paedagogical and practical organisation of the miniproject. Students are provided a common base for all activities.

All the lectures, will be held at Toldkammeret.
Stage introductions and studemts presentations are organized in this room. Supervision will be provided according to the programme in the same room.

Exhibition screens are available for the pinning-up of presentation material, together with a video projector.

Please note that all participating students are responsible for assisting the cleaning-up of the space at the end of the project.



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Marianne Stokholm was introduced to Carmelo di Bartolo and his institute „Instituto Strattura Naturali" during a visit to Milan in 1988. Later Carmelo di Bartolo was invited to Denmark by Marianne import bionics for Danish designers.
Marianne has a special interest in the integrated design process, methods of innovation and the more theoretical and philosophical aspects of design. In bionics she sees possibilities of widening the perspectives for innovative design.

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Jørgen Kepler has worked with design of lightweight structures and composite materials for several years. He has been involved with supervision in the bionics miniprojects at A&D over the last several years.
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Thomas Arvid Jaeger, Architect, Ph.D and assistant professor at Aalborg University.
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Lasse Rosendahl has worked with fluid mechanics and aerodynamics of strangely shaped objects for a number of years, focussing on the free unrestrained motion of cylinders in air flows, and the reduction of drag on body shapes. The flow patterns around solid objects create some of nature's most fascinating views.

Stefan Froholdt,Industrial Design Engineer, Member of the business incubator at the Department of Business Studies AAU. Stefan is developing a business concept, which origins in bionics, into a usable product ready for marked implementation. Stefan's interests are refinement of the design process with focus on the preliminary stages, and improvement of the intuitive use of products. He has experience in transforming principles from nature into an inspiration for product design.

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